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THE 'PENDULUM PARADIGM' - TRENDS IN NITROGEN FERTILISER USE ON TEMPERATE GRASS / CLOVER PASTURES

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ABSTRACT

Nitrogen fertiliser responses, on perennial ryegrass (*Lolium perenne*) / white clover (*Trifolium repens*) dominant pastures, are compared between sub-tropical South Africa and temperate Australia. The data highlight the similarity in inflection point of the response curve, while emphasising the influence of high residual soil N at lower N application rates. The propensity of communities to oscillate between extremes in terms of N fertiliser use on intensive pasture, or the 'Pendulum Paradigm' is discussed. Particular reference is made to the dramatic increase in N fertiliser use in dairy pasture of temperate Australia and New Zealand. Emphasis is given on the potential to achieve the best of both N-fixation, during the warm season, and the strategic application of N fertiliser, during times when clover growth is limited by low temperature.

KEYWORDS

Lolium perenne, *Trifolium repens*, N-fixation, sub-tropics, temperate

INTRODUCTION

The role of legumes in supplying nitrogen (N) in mixed pasture is well established. In most temperate and some subtropical pastoral systems, white clover (*Trifolium repens*) plays a very important role in providing the N requirements of the pasture.

Nitrogen fertiliser rates between 300 and 400 kg N/ha are commonly applied in intensive dairy farms in the United Kingdom (Morrison, 1980; Frame, 1994), Ireland (Crosse and Dillon, 1996) and South Africa (Eckard, 1994; McKenzie, 1994; Eckard, 1996a; McKenzie, 1996). In these countries a high level of pasture production is commonly maintained through the application of nitrogenous fertiliser after each grazing. However, these countries have seen a reduction in N fertiliser inputs in recent years, due to environmental (EC regulations), economic pressures and a concomitant renewed interest in the role of clover-based pastures (Eckard, 1994; Frame, 1994).

At the same time, the strongly legume-based pastoral systems of South Eastern Australia (Eckard, 1996a) and New Zealand (Ball, 1979; Frame, 1994) have seen a rapid swing to higher N fertiliser inputs over the last 15 years.

This paper aims to compare N fertiliser responses on grass/clover pastures in sub-tropical South Africa and temperate Australia. The propensity of communities to swing beyond an optimum into excess, or the 'Pendulum Paradigm', is briefly discussed in the above context.

METHODS

Data are extracted from N fertiliser response trials, conducted under grazing on perennial ryegrass (*Lolium perenne*) / white clover (*Trifolium repens*) pastures, in the sub-tropics of South Africa (29° S) and in the temperate, high rainfall climate of North West Tasmania (42° S). Specific methods employed are detailed in Eckard (1994). Data from the sub-tropics represent the average response from six consecutive applications. Tasmanian data represents the average yield response to a single N application on 10 separate sites. In both cases, N was applied between April and September.

Trends in N fertiliser use in Australia are derived from data supplied by fertiliser companies in Victoria (Anon, 1996). Nitrogen fertiliser trends from other countries are derived from referenced literature.

RESULTS AND DISCUSSION

Extensive research has been conducted world-wide into the N fertiliser responses of intensive pasture systems. In most studies, the shape of the response curve remains essentially similar, with three distinct phases; a sharply rising portion, an inflection point and a portion where yield no longer increases, or may even decrease (Sparrow, 1979a). Numerous studies have attempted to fit regression functions to N response curves with varying degrees of success (Reid, 1970; Boyd *et al.*, 1976; Sparrow, 1979a; Sparrow, 1979b; Eckard, 1986, Eckard, 1994). A detailed review of these response functions is contained in Eckard (1994). Data in Figure 1 show the similarity of N fertiliser response trials conducted in the sub-tropical, eastern South Africa and the temperate, high rainfall climate of North-West Tasmania. There is a marked similarity in the inflection point, above which further increases in N fertiliser applications appear in excess of plant requirements for maximum growth (Figure 1).

Factors affecting N responses have been clearly identified in past research, the largest of which include soil and air temperature, soil nutrients, available moisture and available soil nitrogen (Baker, 1985; Eckard, 1994; Frame, 1994). The main difference between the two response curves in Figure 1 lies in the contribution of residual soil N and legume derived N at lower N fertilisation rates. In the Tasmanian data (Figure 1), the trials were conducted on a highly productive site that had been under perennial ryegrass/clover pasture for many years (high in residual N; organic carbon = 5.8 g/100g). In contrast, the South African site was a one-year old perennial ryegrass/clover pasture sown on an old maize cropping land (low in residual soil N; organic carbon = 2.4 g/100g).

These data may explain some of the negative attitudes towards the strategic use of N fertiliser in long-term clover based pasture systems. Given the large contribution of the clover to the overall N status of the pasture, the addition of small individual top-dressings of N fertiliser are unlikely to result in a substantial increase in pasture yield. However, the data suggest that substantial yield responses may be achieved with individual N applications of between 45 and 50 kg N/ha in any one application. In some of the responses observed in the Tasmanian data, the response curve was sigmoidal, with little or no benefit to less than 30 kg N/ha/application (sigmoidal data not shown) or greater than 45 kg N/ha/application. This trend has been reported in numerous studies (Eckard, 1994; Frame, 1994; McKenzie, 1996).

In spite of the slightly lower responses in the cooler climates, the past 15 years have seen a dramatic increase in N fertiliser use by pasture-based dairy farmers in temperate South Eastern Australia (Figure 2) and New Zealand. Initially, N fertiliser was only used to boost late winter pasture yields. However, it is increasingly being used throughout autumn to spring, and through the summer in many cases.

In contrast, countries like the United Kingdom and South Africa, are now taking a renewed interest in legume-based pasture systems. These changes appear to have been driven by a combination of environmental and economic factors. There is an increasing trend in environmentally-based restrictions on N fertiliser use in the United Kingdom and Ireland (Dowdell, 1986; Magdorf, 1992; Miles and Manson, 1992; Frame, 1994; Crosse and Dillon, 1996). With recent political changes in South Africa, the potential for international trade in dairy products means that farmers will compete at international prices. In these intensive dairy systems, N fertiliser inputs form one of the largest financial inputs next to purchased feeds (Combud, 1993; Eckard, 1994). For this reason, there is now a renewed interest in low-cost legume-based pasture systems in South Africa (Eckard, 1996b).

It has long been accepted that the 'best of both worlds' can be achieved in these pasture systems, with some compromise being accepted. During the warmer months, reliance on N fixation by clover has proven sufficient for a high level of pasture production (Eckard, 1994; Frame, 1994). However, clover growth and N-fixation rate are restricted by lower temperatures during the cooler months, while the perennial ryegrass component is still able to grow (ADAS, 1982; Hart, 1987; Eckard, 1996a). It is during this cooler period that strategic applications of N fertiliser will boost grass production, with minimal negative effect on the clover component in the following season (Ledgard, 1986; Frame, 1994; Eckard, 1996a).

Unfortunately, the paradigms that exist in both research and farming circles result in a global oscillation between either clover-based pastures or highly N-fertilised pastures. Research needs to play an internationally unified role, to prevent the pendulum swing to the extreme, or what could be referred to as a 'Pendulum Paradigm'.

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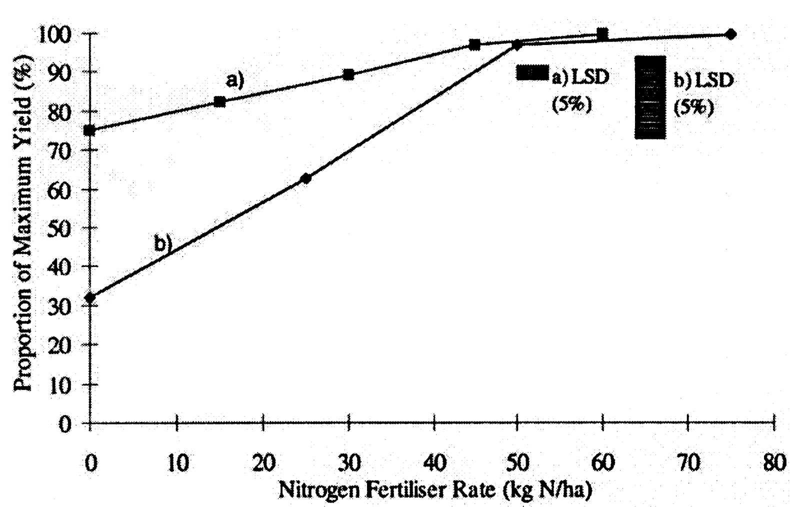
Figure 1

A comparison of nitrogen fertiliser responses on a perennial ryegrass/ clover pasture in, a) the temperate, high rainfall zone of North West Tasmania, and b) the sub-tropics of Eastern South Africa.



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